Synchronized Elephant Population Estimation Tamil Nadu 2024

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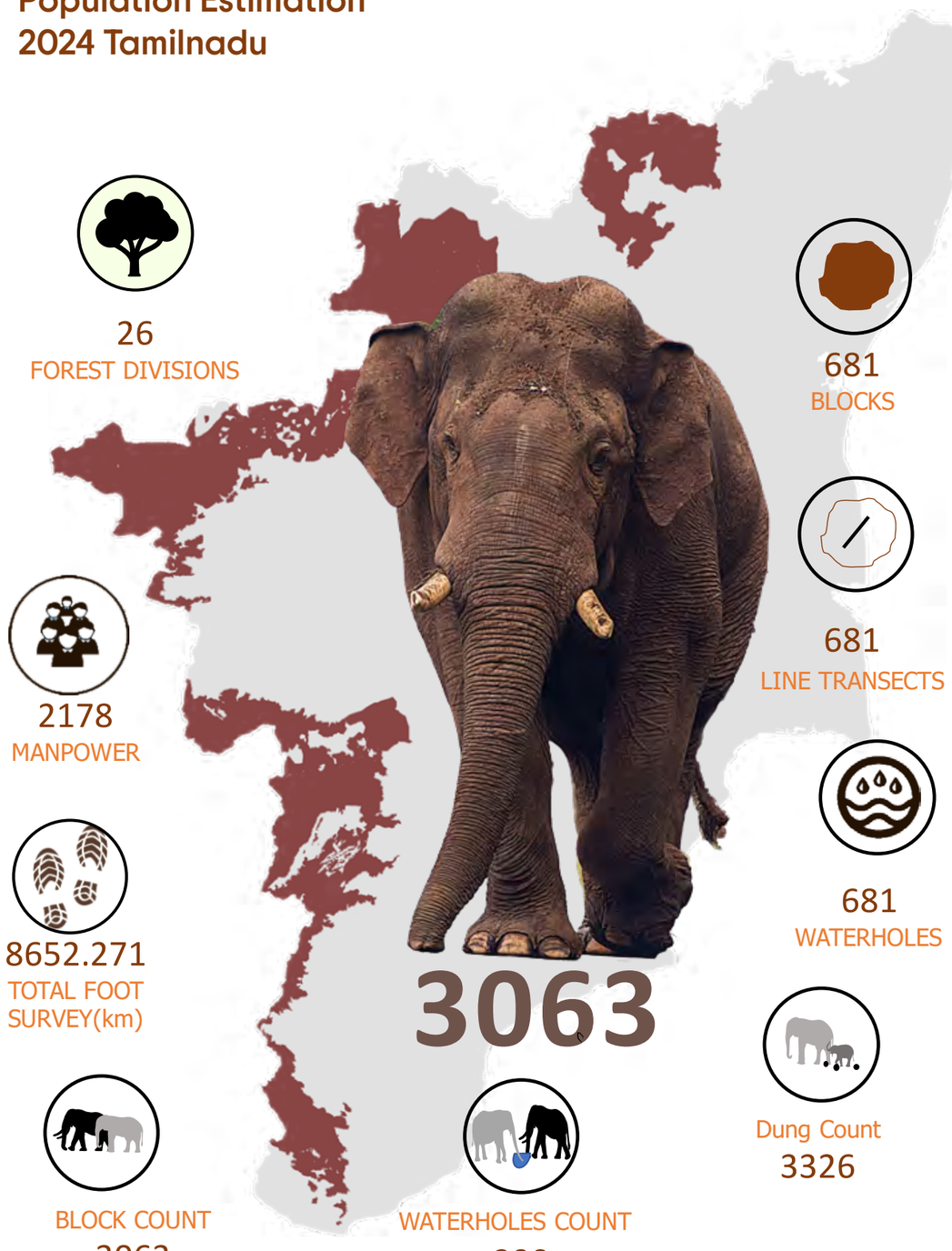


26
FOREST DIVISIONS

681
BLOCKS

681
LINE TRANSECTS

2178
MANPOWER

681
WATERHOLES

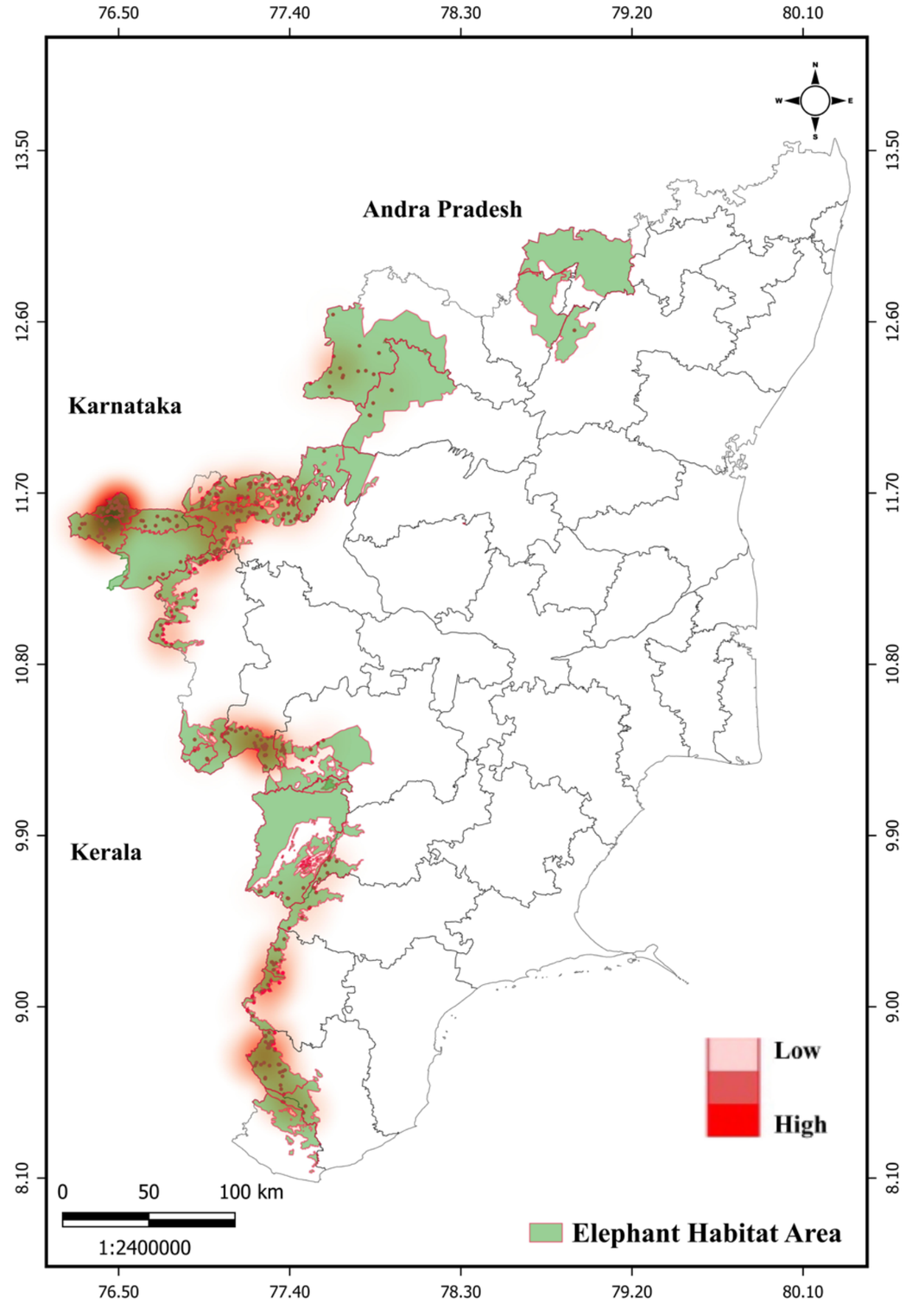
8652.271
TOTAL FOOT SURVEY(km)

3063

Dung Count
3326

BLOCK COUNT
3063

WATERHOLES COUNT
290



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01

1.Introduction

Elephants are flag ship species which play a vital role in maintaining ecological balance/ health in its habitat by limiting the growth of vegetation, facilitating seed germination and dispersal of seeds of plants it feeds on, helping in nutrient recycling and improving fertility of forest soil. About 6000 years ago, Asian elephant are enjoyed a much wider geographic distribution and higher number of population, its distribution is now limited to four non-contiguous regions in North, North East, Central, and Southern India. Currently Asian elephant (Elephas maximus) is listed as an endangered species and listed in Schedule I of the Indian Wildlife Protection Act (1972) due to a decline in the population of over 50% in the past three generations. India holds 60% of the Asian elephant population with an estimated population size of 29,964 (Williams et al., 2020).

The conservation and maintaining a healthy population of wild elephants is highly crucial for maintaining the overall environment/ecosystem. While conservation and management of endangered species (elephants) in the wild requires adequate knowledge of their distribution and population size (Sukumar, 1989; Easa et al., 2002). A precise periodic estimate will enable the managers to monitor population trends and take decisions appropriately. The outcome of such periodic population estimation exercise would help in revisiting the strategies of management of elephant populations and habitat as well as reorienting the efforts of the Forest Department in conflict mitigation measures. Estimation and mapping of elephant population in various Forest Divisions (FDs) and Elephant Reserves (ERs) would serve as an indicator for ensuring water, fodder availability and in assessing the condition of the migratory corridors.

Elephants are typically long-ranging animals and are distributed across landscapes covering different states in India. In southern India, four states being Tamil Nadu, Karnataka, Kerala and part of Andhra Pradesh hold around 15,000 elephants. Therefore conducting synchronized elephant population estimations at regular intervals within each of the four geographical regions to minimize bias in estimation, assessing population trends, and their implications for species management.

Tamil Nadu Forest Department in coordination with neighboring southern states (Kerala, Karnataka & Andhra Pradesh), conducted synchronized elephant population estimation from 23 to 25 May 2024 in the elephants holding ranges of entire state. This exercise aimed to estimate the population of wild elephants by direct (sample block count) and indirect (line transect dung count) methods as recommended by Project Elephant Directorate, Ministry of Environment Forest and Climate Change, Government of India, and also to assess population structure (age-sex composition and sex ratio) using data from direct sightings of elephants at waterholes count in 26 forest divisions which is includes Tiger Reserves, Wildlife Sanctuaries, Territorial Divisions and Mukurthi National Park.

MUDUMALAI
TIGER RESERVE
SYNCHRONIZED ELEPHANT POPULATION ESTIMATION 2024
on 23,24 & 25 MAY 2024
Venue : Advanced Wildlife Management Training Center, Theppakadu, The Nilgiris

2.Training

The training was conducted from May 12 – May 22 2024 various Forest divisions (Table 1). Forest managers (Deputy Conservator of Forest and Assistant Conservator of Forest) and field staff along with volunteers attended the training program. Criteria for selection of sample blocks, location of line transects and surveying waterholes was discussed at this training and later finalized by the concerned officials for various forest divisions.

The field enumeration (sample block count - and line transect indirect dung count) and demographic profiling (water-hole observations) were executed with prescribed methods used by the forest staff with the help of technical experts during May 23-25, 2024.

Table 1

Sl. No	Division	Date of Training	Venue	Trainers
1	MTR- Udhagai Division	22/05/2024	Training Centre Theppakadu	1. Tmt.C.Vidhya.IFS - DD 2 Dr. P. Santhosh Kumar, Biologist 3. Mr. M. Palanisamy, Biologist – MTR Udhagai Division
	Mukurthi National Park	22/05/2024	Mukurthi Range Office	1. Mr. Yuvaraj, FRO, Mukurthi NP
2	MTR-Masinagudi Division	22/05/2024	Singara Range Office &Thengumarada Tracking shed	1.Thiru.P.Arun Kumar, DD 2. Dr. S. Vimal, Biologist, MTR 3. Mr. Dilip Clinton- Biologist, Masinagudi Division
3	Gudalur Forest Division	16/05/2024	Gene Pool Garden	1.Thiru P.Karuppiah, ACF, 2.Dr. S. Vimal, Biologist, MTR
4	Nilgiris Forest Division	21/05/2024	Carnil, Ooty	1.Thiru .K. Kirubakaran , ACF 2.Dr. S. Karthick, Biologist 3. Mr.Girikaran, Biologist, Nilgiri Division
5	Coimbatore Division	15/05/2024	Forest Campus Coimbatore	1. Thiru. Vijayakumar, ACF 2. Mr. M. Naveen , Biologist,Coimbatore Division 3. Mr. J. Peter Pream Charkaravarthi- Biologist -ATR
6	ATR Pollachi Division	22/05/2024	Training Centre Attakatty	1. Mr. K.Anvar Biologist, Pollachi Division
7	ATR- Tiruppur Division	15/05/2024	DD Office Udumalaipet	1. Thiru. Devendra Kumar Meena, IFS 2. Thiru.K. Mahesh Kumar, Biologist-Tirupur Division
8	Dindugal Division	16/05/2024	Forest extension centre Dindugal	1.Thiru. P.M. Rajkumar, IFS 2. Mr. K. Magesh Kumar, Biologist-Tiruppur Division
9	Kodaikanal Division	22/05/2024	Kodaikanal-Meeting hall	1.Thiru. Yogesh Kumar Meena, IFS 2. Mr. J. Peter Pream Charkaravarthi- Biologist -ATR

Sl. No	Division	Date of Training	Venue	Trainers
10	Erode Division	15/05/2024	Anthiyur Range	2. Mr. J. Dalson Mani, Biologist, Erode Division 3. Mr. C. Sakthivel, Biologist-Sathyamangalam Division
11	Salem Division			
12	STR-Sathyamangalam Division	16/05/2024	Bannari Awareness centre	1. Thiru. Kulal Yogesh Vilas, IFS 2. Mr. C. Sakthivel, Biologist Sathyamangalam Division
13	STR-Hasanur Division	16/05/2024		1.Thiru, K.Sudhagar, IFS, DD 2. Mr.C.Sakthivel, Biologist 3. Mr. G. Karthikeyan , Biologist
14	Dharamapuri Division	14/05/2024	DFO Office campus , Dharampuri	1. Thiru. K. Rajangam, IFS, DFO 2. Mr. C. Sakthivel, Biologist Sathyamangalam Division
15	Hosur Division	13/05/2024	DFO office campus , Hosur	1.Selvi K.Karthikeyani, IFS 2. Mr..C. Sakthivel, Biologist Sathyamangalam Division 3. Mr.S,Thangamani ,Biologist, Hosur Division
16	Tirupattur Division			
17	Vellore Division			
18	Thiruvannamalai Division			
19	SMTR-Megamalai Division	21/05/2024	DD Office Campus, Theni	1. Thiru. S. Anand I.F.S., DD 2. Mr. D. Keerthivasan, Biologist -Megamala
20	Theni Division	22/05/2024	DFO Campus, Theni	Mr.D. Keerthivasan, Biologist, Megamalai Division
21	Madurai Division	22/05/2024	DFO office	1. Mr.D. Keerthivasan, Biologist, Megamalai Division 2. Mr. Annakodi,FRO, Usilambati Range ,FRO- Usilambati Range
22	SMTR-Srivilliputtur Division	15/05/2024	DD Office , Srivilliputtur	1.Thiru. P.Devaraj I.F.S., DD 2. Mr.Parthiban, Biologist, Srivilliputhur Division
23	KMTR-Kalakadu Division	15/05/2024	Kalakad Range	1. Thiru. Rameshwaran, DD 2. Mr. N.Sridharan, Ecologist Biologist –KMTR 3. Tmt.S. Agnies Jeya Packiavathi , Biologist, KMTR
24	KMTR-Ambai Division	16/05/2024	Mundanthurai Range	1. Mr. N.Sreedhar, Ecologist-KMTR 2.Tmt.S. Agnies Jeya Packiavathi , Biologist, KMTR
25	Kanyakumari Division	12/05/2024	Kanyakumari Division	1.Thiru. E. Prasanth, IFS 2. Mr. N.Sridharan, Ecologist – KMTR
26	Tirunelvelli Division	16/05/2024	Kutralam Range	1.Dr.R.Murugan, IFS, 2.Dr.R. Kandhasamy, Biologist, Tirunelvelli Division

3.Methodology

Estimation of wildlife population with precision and accuracy is essential in wildlife management (Williams et al., 2002). Among various methods in vogue over the past 3-4 decades in estimating elephant populations, two have been consistently employed in Tamil Nadu since 2002 considering their relative simplicity and the capacity of a large force of frontline forest staff to employ the methods in the field with least possible training. To study the population structure, water hole count is employed.

a. Direct sighting of elephants using “sample block count” method

b. Indirect estimate using line transect (dung count) method

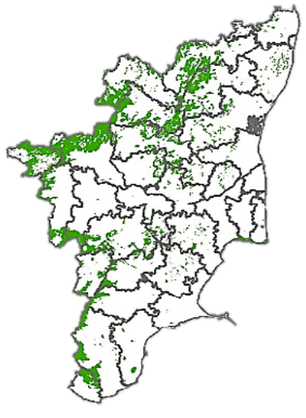
c. Waterhole count - Population structure

Sampled Area

Wild elephants have been reported in 26 forest divisions of Tamil Nadu and the total area of elephant distribution divisions is approximately 17737.31 Sq.km, among these, effective elephant habitats comprise 8989.63 Sq.km of which 3277.87 Sq.km areas (36%) were sampled during this population estimation in the state (Table 2).

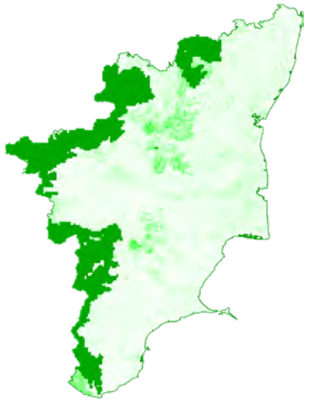
Tamil Nadu state has presently five notified Elephant Reserve namely Nilgiri Elephant Reserve (4662 Sq.km), Coimbatore Elephant Reserve (566 Sq.km), Anamalai Elephant Reserve (1457 Sq.km), Srivilliputtur Elephant Reserve (1249 Sq.km) and Agsthyamalai Elephant Reserve (1197 Sq.km).

This encompasses an area of nearly 9131 Sq.km, ranging from the wet evergreen forest through deciduous forest to dry thorn forest, harbouring one of the largest populations of Asian elephants. Totally 2178 persons (1836 numbers of Forest Department Staff and 342 numbers of Volunteers) were involved in the elephant population estimation exercise.



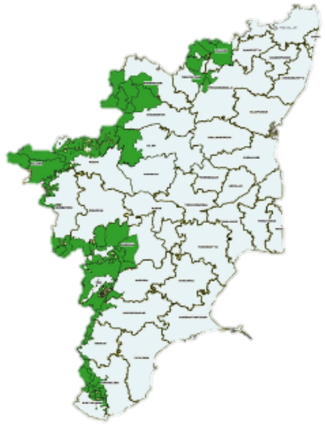
17737.31 Sq.km

Total area



8989.63 Sq.km

Elephant habitat



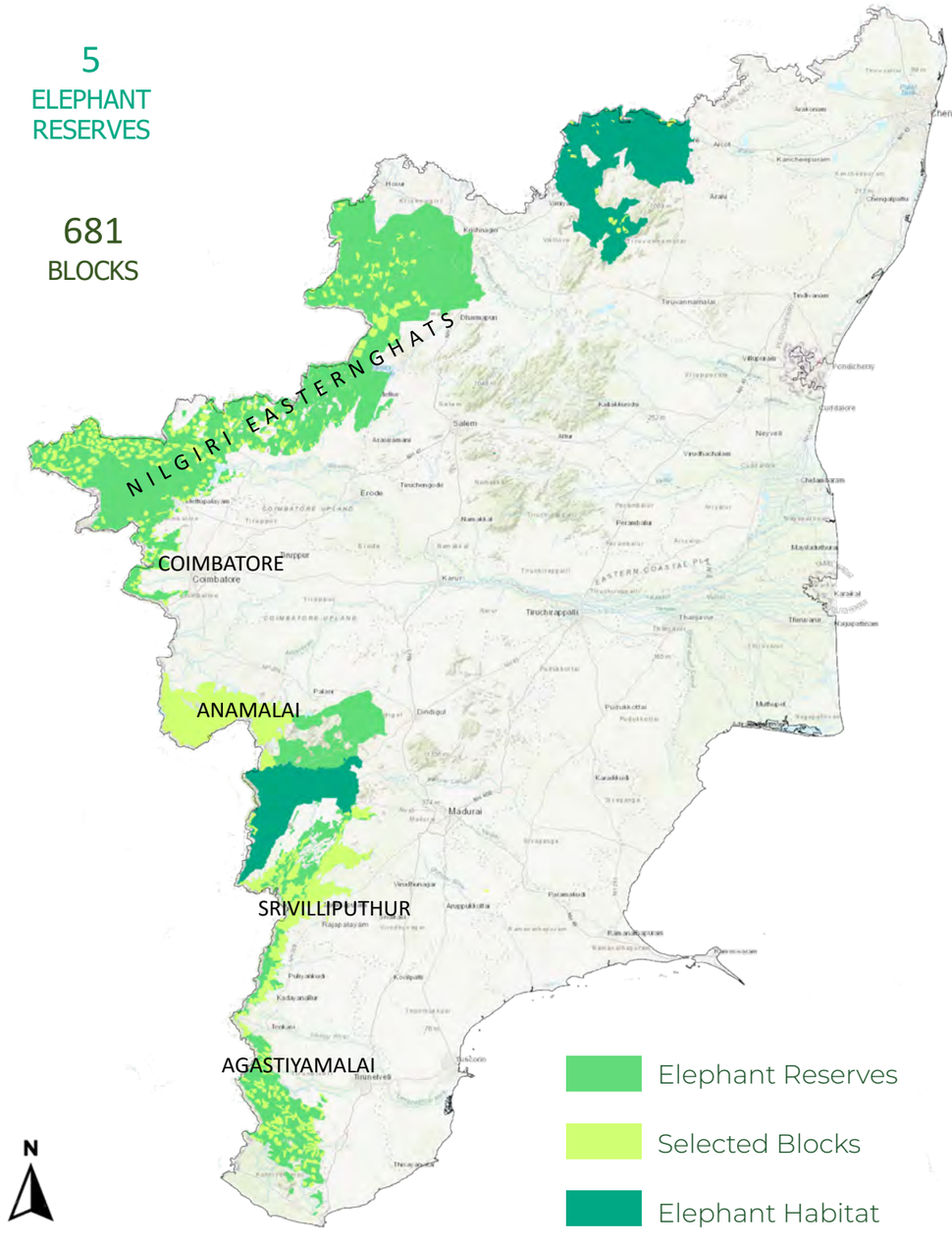
3277.87 Sq.km

Sampled area

26
FOREST DIVISIONS

5
ELEPHANT RESERVES

681
BLOCKS

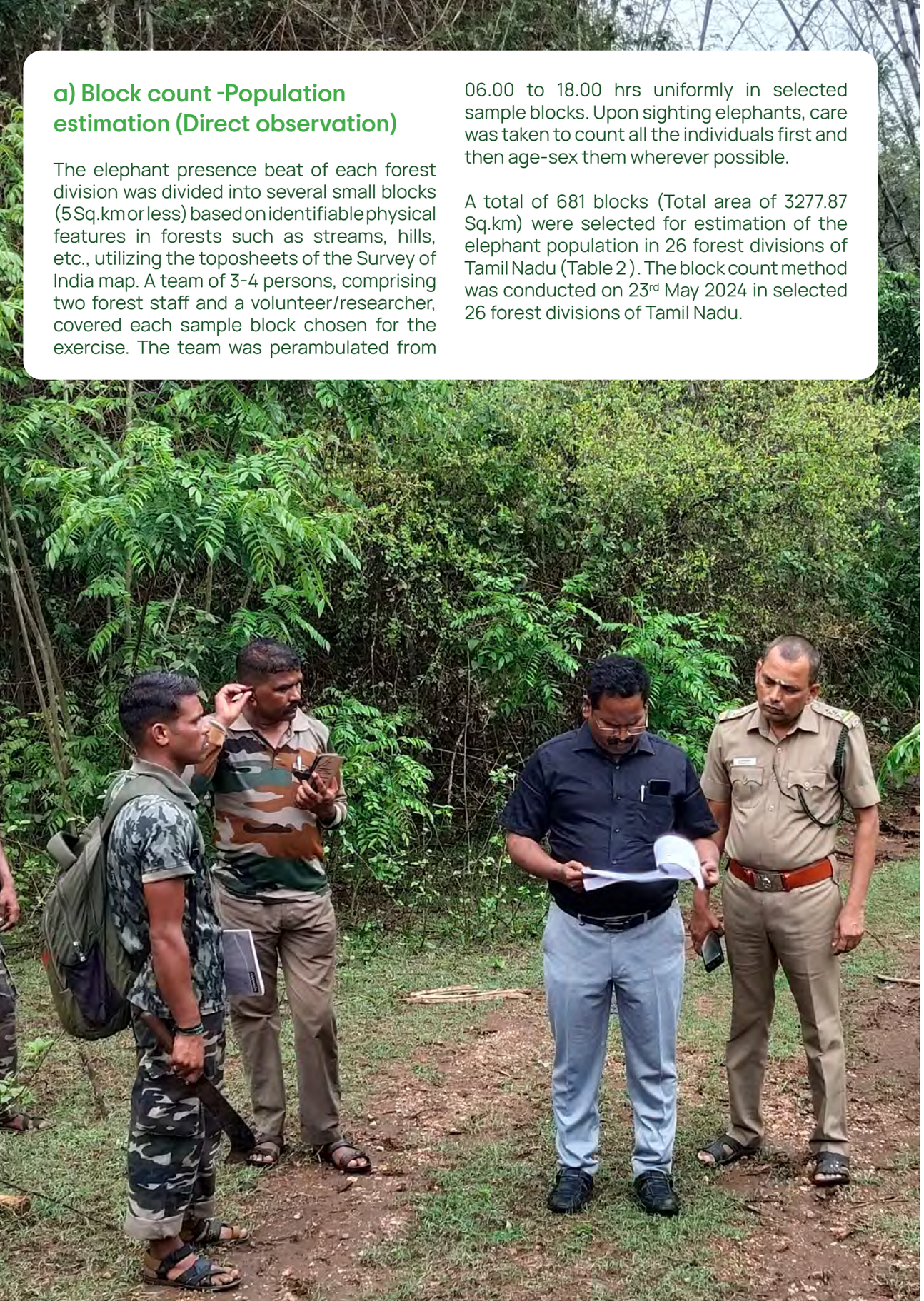


Map showing the selected sample blocks for Synchronized Elephant Population Estimation 2024 in Tamil Nadu

a) Block count -Population estimation (Direct observation)

The elephant presence beat of each forest division was divided into several small blocks (5 Sq.km or less) based on identifiable physical features in forests such as streams, hills, etc., utilizing the toposheets of the Survey of India map. A team of 3-4 persons, comprising two forest staff and a volunteer/researcher, covered each sample block chosen for the exercise. The team was perambulated from 06.00 to 18.00 hrs uniformly in selected sample blocks. Upon sighting elephants, care was taken to count all the individuals first and then age-sex them wherever possible.

A total of 681 blocks (Total area of 3277.87 Sq.km) were selected for estimation of the elephant population in 26 forest divisions of Tamil Nadu (Table 2). The block count method was conducted on 23rd May 2024 in selected 26 forest divisions of Tamil Nadu.



Data Analysis

Data collected from the field exercise includes details of the number of elephants counted (yj), the area sampled (xj), and the total area of the division (Xj). Estimates of variance for sample blocks of unequal sizes are provided in Caughley (1977) and by Indian Statistical Institute (Kolkata) in Lahiri-Choudhury (1991). The formula used for estimating elephant density and elephant number along with variance, standard error, and 95% confidence intervals is as follows:

- Estimating elephant number (Y)
  $(y/x) \times X$

- Estimating variance *(v)*

$$v = \frac{X^2}{(n(n-1)} \times \sum_{j=1}^{n} \frac{(y_j - y)^2}{(x_j - x)^2}$$

Estimating standard error
√v = standard error of the estimate of the total elephant population

Estimate of 95% Confidence Interval(CI)
CI= [(Estimate(Y)−1.96×√v), ((Y)+1.96×√v)]

CI= Estimate of the upper and lower confidence interval of the total elephant population for a given forest division or stratum

Where,

X = Total area of the region (Forest Division)

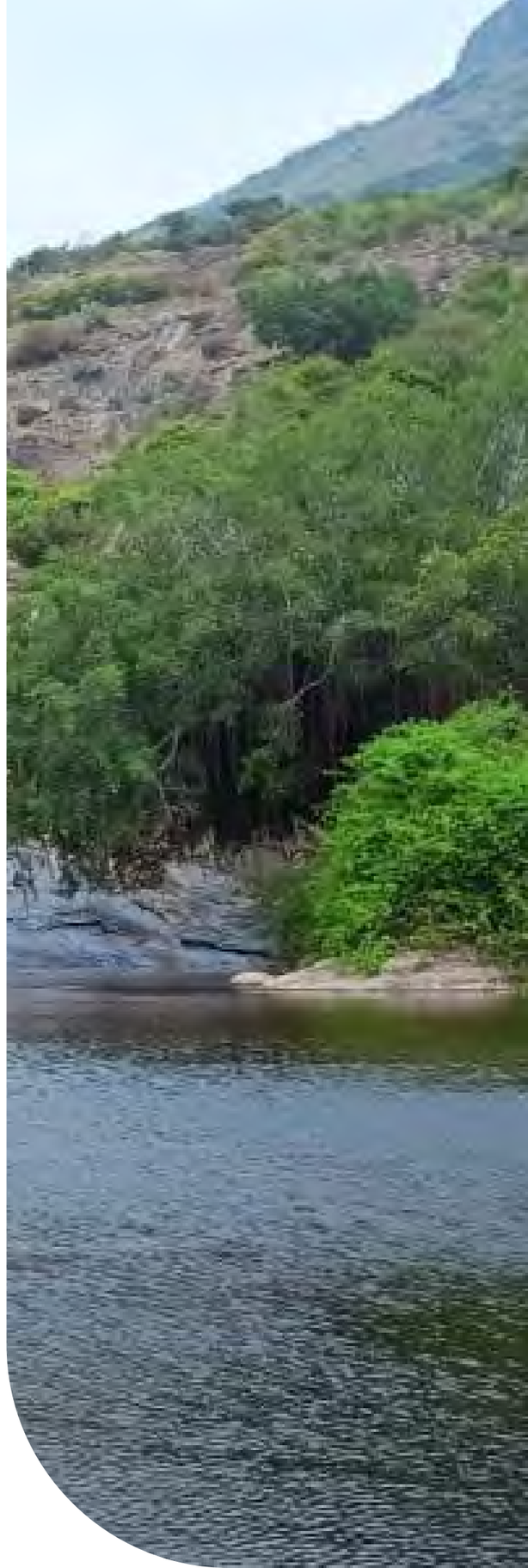
n = Total Number of blocks in that region (Forest Division)

yj = No. of elephants in the j^{th} block j=1,2,…,n

xj = Area in Sq.km of the j^{th} block

y = The total number of elephants counted in all sample blocks

x = Total area (in Sq.km) of all sample blocks
(y/x) = Estimate of elephant density/Sq.km



b) Dung Count in Line transects - Population Estimation (Indirect observation)

Line transects (Burnham et al., 1980) were laid in all the forest divisions in the same blocks where sample block count was undertaken. In each sample block, a transect of a maximum length of 2 km was laid across an altitudinal gradient and walked once to enumerate dung piles. On sighting dung piles, the perpendicular distance of the dung pile from the line was recorded. A total of 681 line transects were selected for the count of elephant dung in 26 forest divisions of Tamil Nadu (Table 8). The line transect dung count method was conducted on 24th May 2024 in selected 26 forest divisions of Tamil Nadu.

Data Analysis

Data analysis: Line-transect dung count data were used to estimate dung density using Distance Software (Version 7.5). This dung density was converted into elephant density by using the computer programme Distance Software (Version 7.5) by incorporating the elephant defecation rate and elephant dung decay rate following the formula of Barnes & Jenson (1987) given below. In the absence of specific data for different elephant populations in the state, the defecation rate of 16.33 (SE = 0.08) calculated by Watve (1992) and the decay rate of 0.0097 dung piles/day (SE = 0.002) calculated by Varma et al. (1995), both at Mudumalai Wildlife Sanctuary (Nilgiri ER), were used in the present analysis.

$$\text{Density of elephants (E)} = \frac{Y \times r}{D}$$

Y = Density of dung
r = Daily rate of dung decomposition
D = The number of dung piles deposited/ elephant/day

The dung data were analyzed by evaluating different models of detection probability (half-normal, uniform, and hazard rate) with cosine adjustment available in Distance software. The best-fit model for each dataset was assessed using Akaike's Information Criterion (AIC) value. Below formula was used for estimating the elephant population in Tamil Nadu using the line transect dung count method.

Estimating elephant number **(Y) = E x X**
E=Elephant density
X= Effective elephant habitat

C) Waterhole Count - Population Structure

The data on population structure were collected during the sample block count in all the forest divisions wherever possible and by monitoring waterholes as age-sexing elephants is easier at the waterhole due to better visibility. On every sighting of an elephant, the sex was differentiated based on the presence or absence of a tusk for individuals above two years. Individuals <2 years were sexed and special care was taken to differentiate tuskless males (makhana) based on characteristic features such as the presence of penis sheath, slanting back, broad musculature at trunk base, and the social context of the individual (solitary sub-adult or adult without tusks).

The age of elephants was classified into four major classes based on their shoulder heights following Sukumar etal. (1988). The categories are calf (<1 yr old; <120 cm height), juvenile (1–5 yrs old; 121–180 cm), sub-adults (5–15 yrs old; 181–210 cm for female and 181–240 for male) and adults (15 yrs; >210 cm for female and >240 cm for male). Individuals were recorded as 'Unidentified' if they could not be categorized into a specific age and sex. The waterhole count method was conducted on 25th May 2024. A total of 681 waterholes were selected for the population structure of the elephant population in 26 forest divisions of Tamil Nadu.

4. Results

4.1 Block Count

a) Population Estimation

A sample block count was conducted in 26 selected forest divisions of Tamil Nadu, among these divisions elephants were sighted in 21 forest divisions. Five forest divisions (Madurai, Theni, Salem, Tirupattur, and Vellore) and Mukurthi National Park do not report any single sightings of elephants, though the occasional use of some of these areas by solitary bulls and herds cannot be ruled out.

Tamil Nadu

Total of 681 sample blocks (with an extent of 3277.87 Sq.km and total 8652.271 km walked) were sampled in the State, of which a total of 1117 elephants were counted (Table 2). The density of wild elephants in State was thus estimated at 0.34 (SE 0.001) per Sq.km and estimated elephant population at 3063 with 95 % confidence interval, ranging from 3054 to 3071 (Table 5).

Forest Division

Among the 26 forest divisions MTR- Udhagai Division has been recorded the highest estimated density (1.12/ Sq.km; n=271) followed by Gudalur Forest Division (0.87/ Sq.km; n=131), MTR-Masinagudi Division (0.75/ Sq.km; n=263), and Coimbatore Forest Division (0.62/ Sq.km; n=336). The estimated elephant population and elephant density based on the sample block count method for various forest divisions were given in table 5 and Fig.5.

Elephant Reserve

Among the five Elephant Reserves, Nilgiris Eastern Ghtas (Nilgiris) Elephant Reserve has been recorded the highest estimated density (0.51/ Sq.km; n=2253) followed by Nilambur-Silent Valley-Coimbatore (Nilambur) Elephant Reserve (0.50/ Sq.km; n=323), Agasthyamalai Elephant Reserve (0.26/ Sq.km; n=259), Anamalai-Parambikulam (Anamalai) Elephant Reserve (0.24/ Sq.km; n=310), and Periyar (Srivalliputhur) Elephant Reserve (0.18/ Sq.km; n=277). The estimated elephant population and elephant density based on the sample block count method for five Elephant Reserves is given in table 6.

Landscapes

According to the landscape wise, Western Ghats has been recorded the highest estimated density (0.36/ Sq.km; n=1806) compared to Eastern Ghats Landscapes (0.27/ Sq.km; n=1104). The estimated elephant population and elephant density based on the sample block count method for Landscapes is given in table 7.

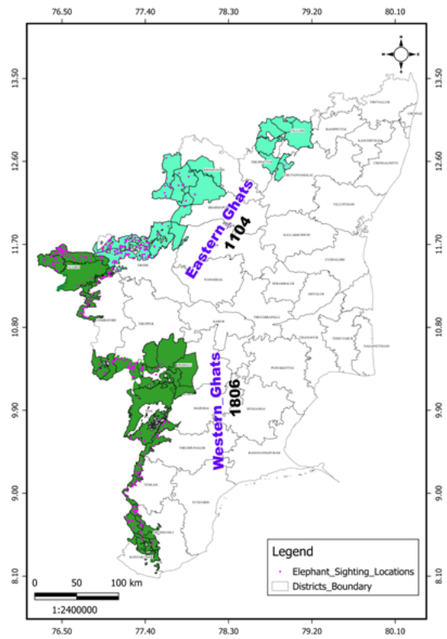
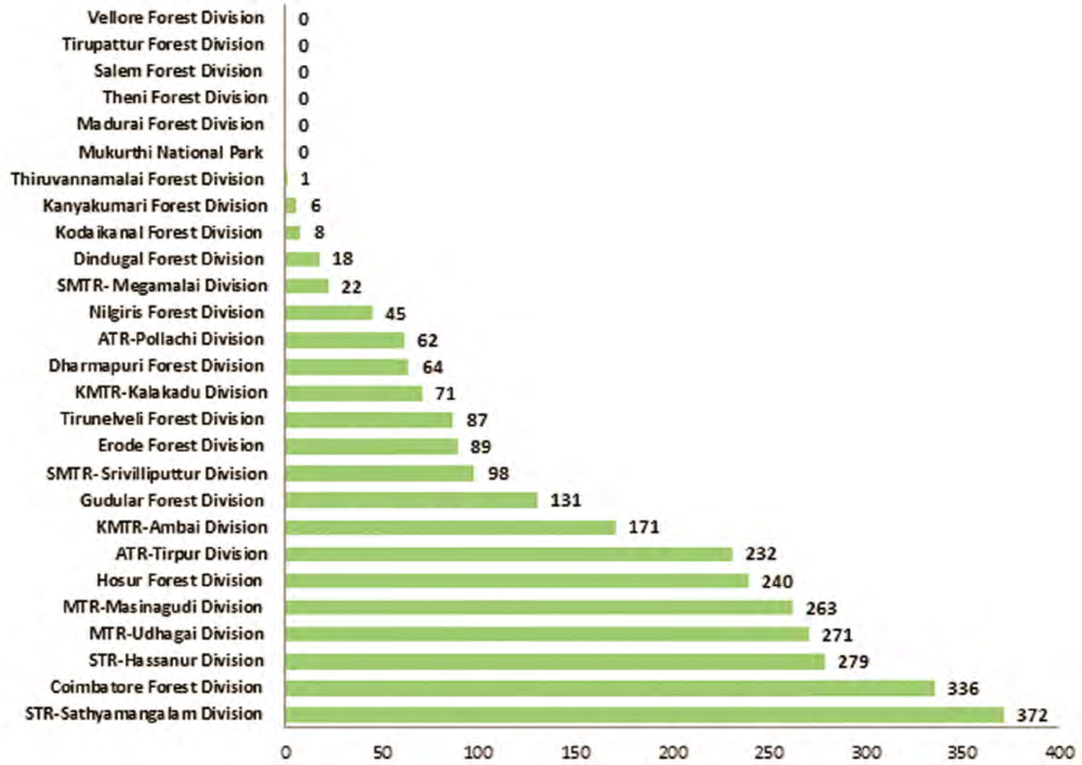


Table 2: Details of sampled area and number of elephants counted in various forest divisions in Tamil Nadu

Sl. No	Name of the Division	Total area (km^2)	Effective elephant habitat (km^2)	No of Blocks	Total area sampled (km^2)	% of sampled area	Number of elephants counted	Makhna
1	MTR-Udhagai Division	241	241	24	120	50	135	4
	Mukurthi National Park	78.46	40	4	20	50	0	0
2	MTR-Masinagudi Division	447.5	347.73	33	156.1	45	118	0
3	Nilgiris Forest Division	501.03	140	14	61.94	44	20	0
4	Gudular Forest Division	464.18	149.35	30	111.43	75	98	1
5	ATR-Pollachi Division	511.82	350	34	170	49	30	0
6	ATR-Tirpur Division	597.25	597.25	53	265	44	103	0
7	Coimbatore Forest Division	693	542.24	42	170.91	32	106	0
8	STR-Sathyamangalam Division	881.31	881.31	45	225	26	95	0
9	STR-Hassanur Division	573.99	573.99	30	150	26	73	0
10	Erode Forest Division	821.47	784.57	28	123.77	16	14	0
11	SMTR- Megamalai Division	626.27	517.82	68	324.91	63	14	0
12	SMTR- Srivilliputtur Division	489.3	439.61	35	175	40	39	0
13	Madurai Forest Division	278.84	45.12	3	15	33	0	0
14	Theni Forest Division	435.77	50.81	4	19.08	38	0	0
15	KMTR-Ambai Division	602.04	416.14	37	185	44	76	1
16	KMTR-Kalakadu Division	328.63	286.4	34	170	59	42	0
17	Kanyakumari Forest Division	427.78	258.4	18	90	35	2	0
18	Tirunelveli Forest Division	326.86	195.72	35	175	89	78	0
19	Dindugal Forest Division	822.59	165	13	65	39	7	0
20	Kodaikanal Forest Division	523	140	17	85	61	5	0
21	Salem Forest Division	709	21.13	1	5	24	0	0
22	Dharmapuri Forest Division	1669.64	369.66	15	75	20	13	1
23	Hosur Forest Division	1492	1000	40	200	20	48	0
24	Tirupattur Forest Division	723.87	74.08	4	20	27	0	0
25	Vellore Forest Division	1031.75	347.57	17	85	24	0	0
26	Thiruvannamalai Forest Division	1438.96	14.73	3	14.73	100	1	0
	Total	17737.31	8989.63	681	3277.87	36	1117	7

Figure 5: Estimated elephant population in 26 forest division of Tamil Nadu using sample block count method



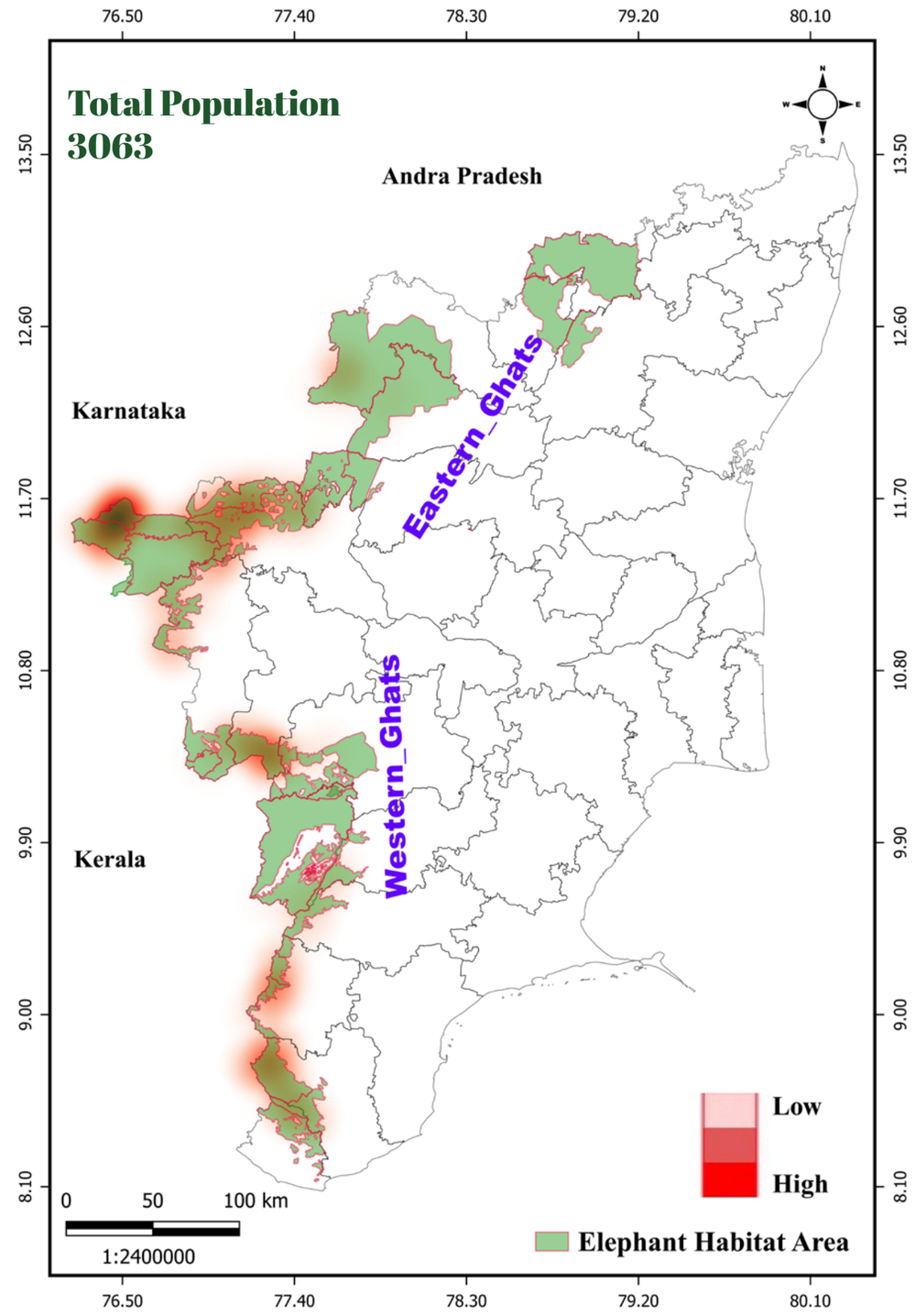
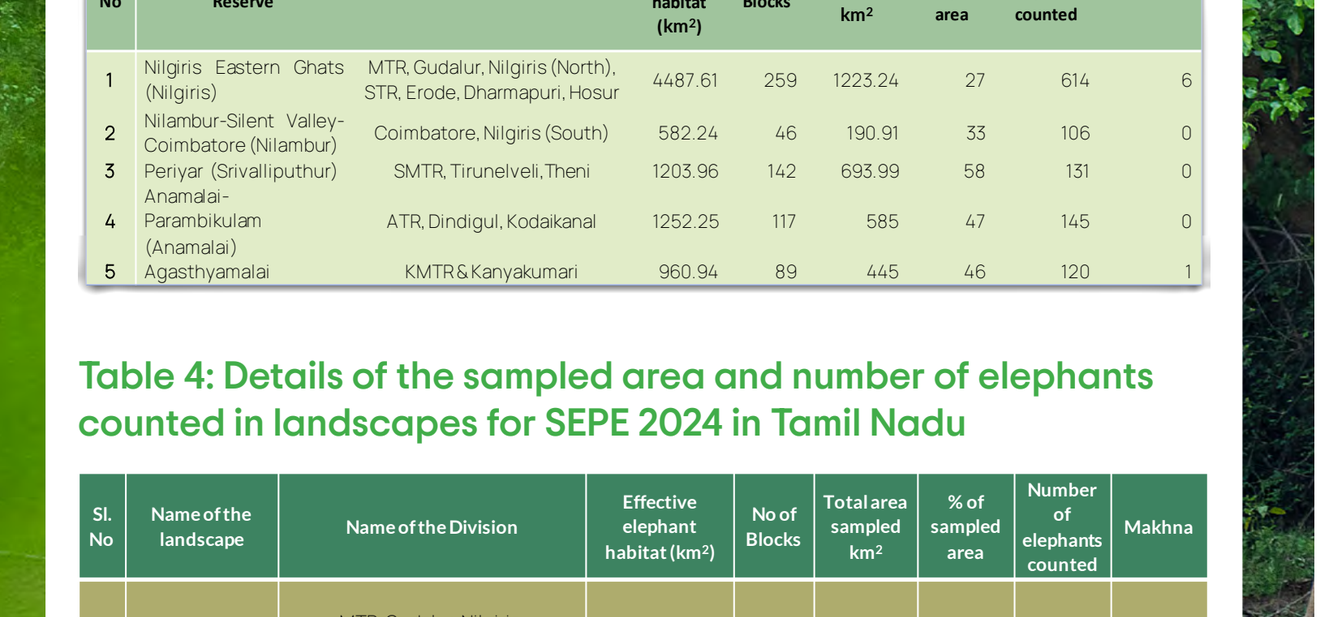


Table 3: Details of the sampled area and number of elephants counted in Elephant Reserves for SEPE 2024 in Tamil Nadu

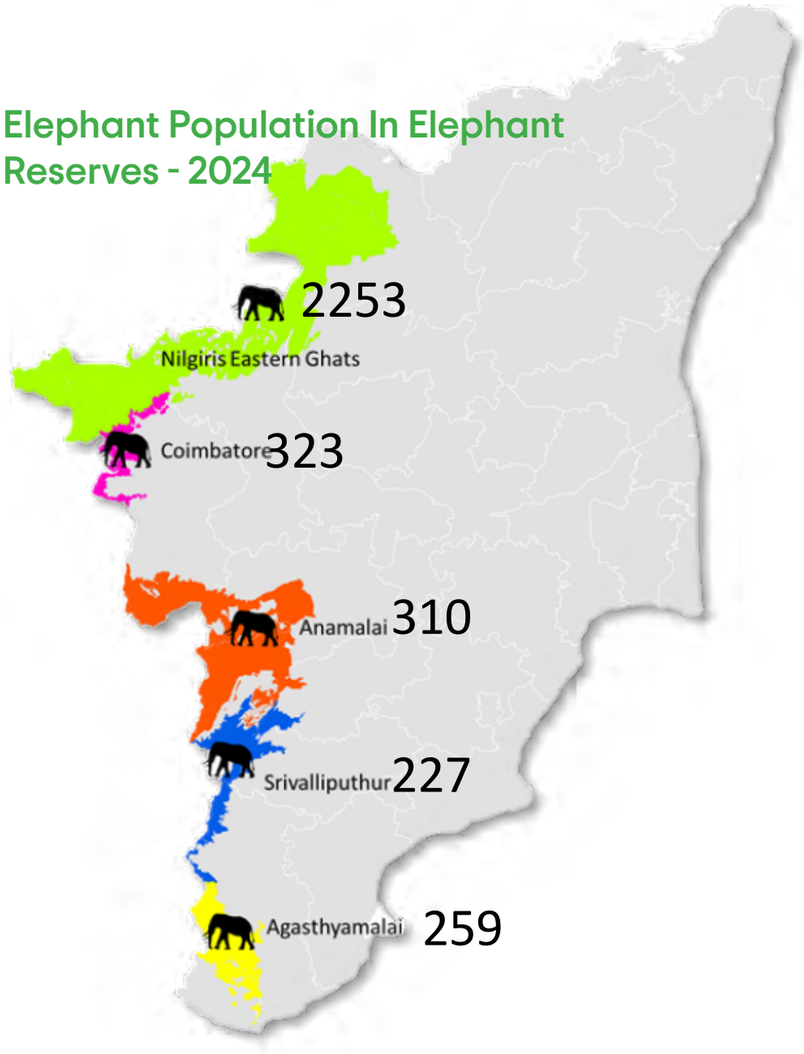
Sl. No	Name of the Elephant Reserve	Name of the Division	Effective elephant habitat (km^2)	No of Blocks	Total area sampled km^2	% of sampled area	Number of elephants counted	Makhna
1	Nilgiris Eastern Ghats (Nilgiris)	MTR, Gudalur, Nilgiris (North), STR, Erode, Dharmapuri, Hosur	4487.61	259	1223.24	27	614	6
2	Nilambur-Silent Valley-Coimbatore (Nilambur)	Coimbatore, Nilgiris (South)	582.24	46	190.91	33	106	0
3	Periyar (Srivalliputhur)	SMTR, Tirunelveli, Theni	1203.96	142	693.99	58	131	0
4	Anamalai-Parambikulam (Anamalai)	ATR, Dindigul, Kodaikanal	1252.25	117	585	47	145	0
5	Agasthyamalai	KMTR & Kanyakumari	960.94	89	445	46	120	1

Table 4: Details of the sampled area and number of elephants counted in landscapes for SEPE 2024 in Tamil Nadu

Sl. No	Name of the landscape	Name of the Division	Effective elephant habitat (km^2)	No of Blocks	Total area sampled km^2	% of sampled area	Number of elephants counted	Makhna
1	Western Ghats	MTR, Gudalur, Nilgiris, Coimbatore, ATR, Dindigul, Kodaikanal, Madurai, SMTR, Theni, KMTR, Kanyakumari, Tirunelveli	4922.59	498	2379.37	48	873	6
2	Eastern Ghats	STR, Erode, Dharamapuri, Hosur, Salem, Tirupattur, Vellore, Thiruvannamalai	4067.04	183	898.5	22	244	1



Elephant Population In Elephant Reserves - 2024



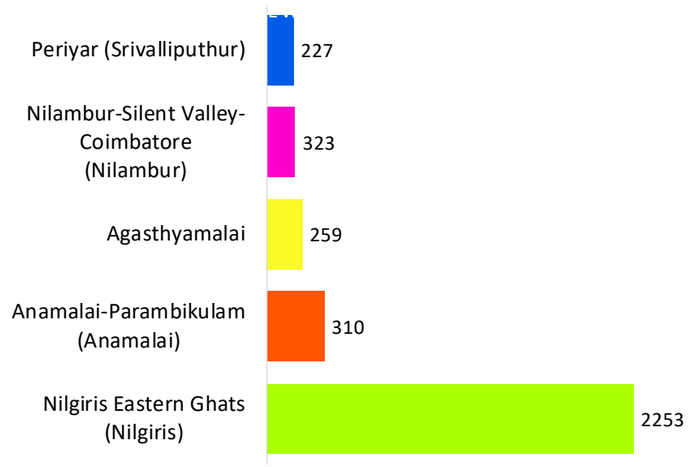


Table 5: Estimated elephant population in Tamil Nadu (26 Divisions) using sample block count method

Sl. No.	Name of the Division	Estimated population	SE	LCL	UCL	Density (No./km²)	SE
1	MTR-Udhagai Division	271	11.54	248	294	1.12	0.09
	Mukurthi National Park	NA	NA	NA	NA	NA	NA
2	MTR-Masinagudi Division	263	8.09	247	279	0.75	0.04
3	Nilgiris Forest Division	45	3.39	39	52	0.32	0.04
4	Gudular Forest Division	131	4.50	124	142	0.87	0.04
5	ATR-Pollachi Division	62	1.84	58	66	0.17	0.01
6	ATR-Tirpur Division	232	4.42	223	241	0.38	0.01
7	Coimbatore Forest Division	336	8.10	320	352	0.62	0.02
8	STR-Sathyamangalam Division	372	8.36	356	388	0.42	0.01
9	STR-Hassanur Division	279	9.40	260	298	0.48	0.03
10	Erode Forest Division	89	6.61	76	102	0.11	0.009
11	SMTR- Megamalai Division	22	0.33	21	23	0.04	0.001
12	SMTR- Srivilliputtur Division	98	2.84	92	104	0.22	0.01
13	Madurai Forest Division	NA	NA	NA	NA	NA	NA
14	Theni Forest Division	NA	NA	NA	NA	NA	NA
15	KMTR-Ambai Division	171	4.68	162	180	0.41	0.02
16	KMTR-Kalakadu Division	71	2.11	67	75	0.24	0.01
17	Kanyakumari Forest Division	6	0.33	6	7	0.02	0.003
18	Tirunelveli Forest Division	87	2.86	81	93	0.44	0.02
19	Dindigul Forest Division	18	1.48	15	21	0.10	0.04
20	Kodaikanal Forest Division	8	0.50	7	9	0.05	0.005
21	Salem Forest Division	NA	NA	NA	NA	NA	NA
22	Dharmapuri Forest Division	64	4.47	55	73	0.17	0.02
23	Hosur Forest Division	240	6.08	228	252	0.24	0.01
24	Tiruppattur Forest Division	NA	NA	NA	NA	NA	NA
25	Vellore Forest Division	NA	NA	NA	NA	NA	NA
26	Thiruvannamalai Forest Division	1	NA	NA	NA	NA	NA
	Total	3063	4.5	3054	3071	0.34	0.001

Forest Division Wise Elephant Sighting

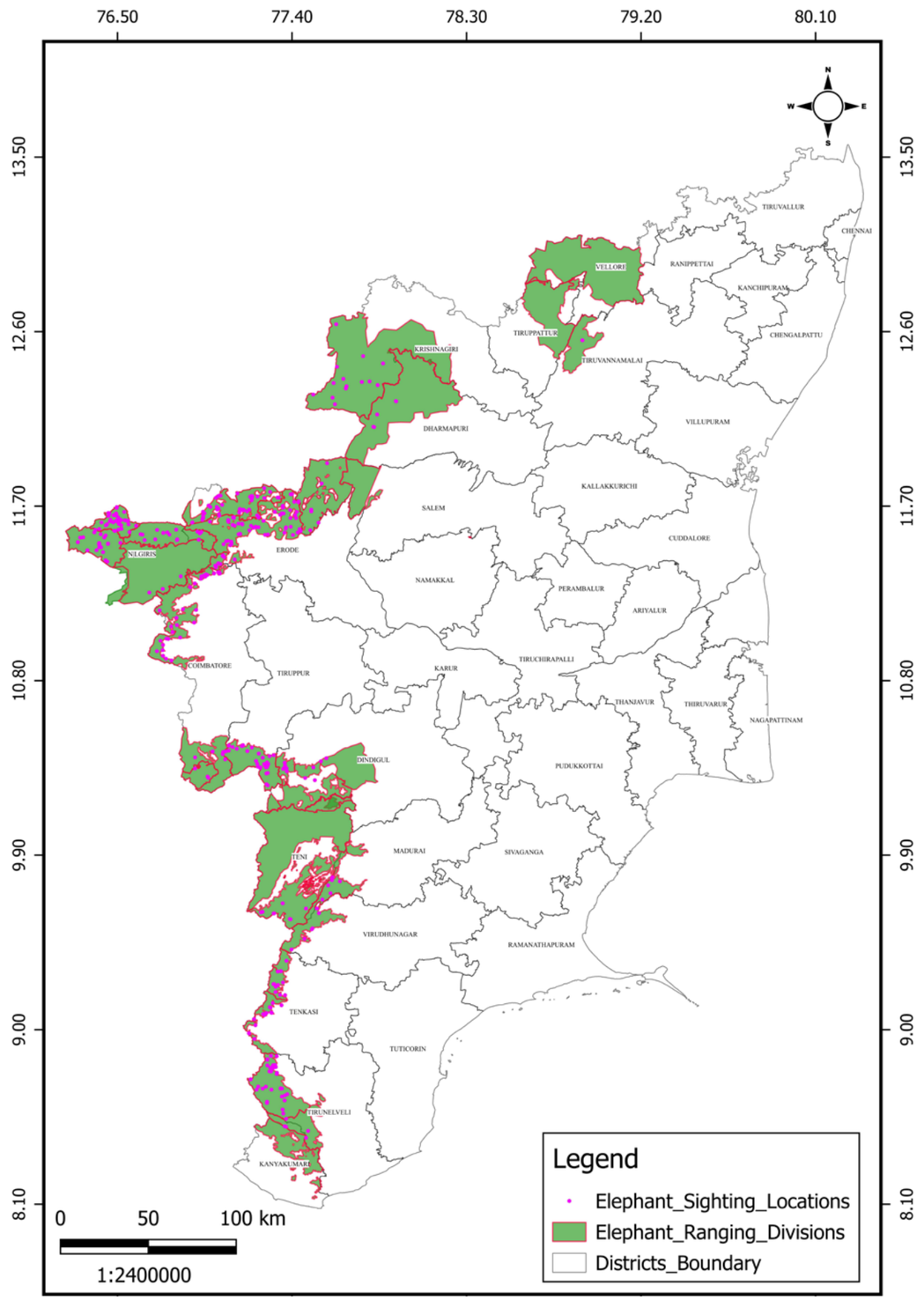


Table 6: Estimated elephant population in elephant reserves in Tamil Nadu using sample block count method

Sl. No.	Name of the Elephant Reserve	Estimated population	SE	LCL	UCL	Density (No./km²)	SE
1	NilgirisEastern Ghats (Nilgiris)	2253	8.71	2236	2270	0.51	0.003
2	Nilambur-Silent Valley-Coimbatore (Nilambur)	323	7.10	309	337	0.50	0.002
3	Periyar (Srivalliputhur)	227	1.60	224	230	0.18	0.002
4	Anamalai-Parambikulam (Anamalai)	310	2.66	305	315	0.24	0.004
5	Agasthyamalai	259	3	253	265	0.26	0.01

Table 7: Estimated elephant population in landscape of Tamil Nadu using sample block count method

Sl. No.	Name of the landscape	Estimated population	SE	LCL	UCL	Density (No./km²)	SE
1	Western Ghats	1806	3.63	1799	1813	0.36	0.001
2	Eastern Ghats	1104	6.65	1090	1117	0.27	0.003

4.2 LINE TRANSECT

In total, 681 transects were laid and covering a distance of 1364.57 km to estimate the dung density of 26 forest divisions in the state. Elephant dung was sighted in all the forest divisions of Tamil Nadu.

Tamil Nadu

The elephant dung density was 682.13 (SE 43.29) per Sq.km in Tamil Nadu. Estimated Elephant density was 0.37 (SE 0.08) per Sq.km in the State. Lower Confidence Limit (LCL) was 0.24/Sq.km and Upper Confidence Limit (UPL) was 0.56/ Sq.km. The estimated elephant population for the State was 3326 (Table 8 & Figure 6) .

Forest Division

Among the 26 forest divisions, MTR-Udhagai Division have been recorded the highest estimated density of elephants (1.89/Sq.km; n=455) followed by MTR Masinagudi Division (1.05/Sq.km; n=364) and STR-Hassanur Division (0.67/Sq.km; n=385). The estimated elephant dung density, elephant density, and estimated elephant population based on the line transects method for various forest divisions were given in table 8 & Fig.6.

Elephant Reserve

Among the five Elephant Reserves, Nilgiris Eastern Ghats (Nilgiris) Elephant Reserve has been recorded the highest estimated density (0.79/Sq.km; n=3564) followed by Nilambur-Silent Valley-Coimbatore (Nilambur) Elephant Reserve (0.47/Sq.km; n=277), Periyar (Srivalliputhur) Elephant Reserve (0.16/Sq.km; n=200), Anamalai-Parambikulam (Anamalai) (0.13/Sq.km; n=164) and Agasthyamalai Elephant Reserve (0.11/Sq.km; n=105). The estimated elephant dung density, elephant density and elephant population based on the Line transects method of five Elephant Reserves were given in table 9.

Landscapes

According to the landscape wise, Western Ghats has been recorded the highest estimated density (0.31/ Sq.km; n=1523) compared to Eastern Ghats Landscapes (0.28/ Sq.km; n=1134) (Table 10).

Figure 6. Estimated elephant population in 26 forest division of Tamil Nadu using line transect dung count method

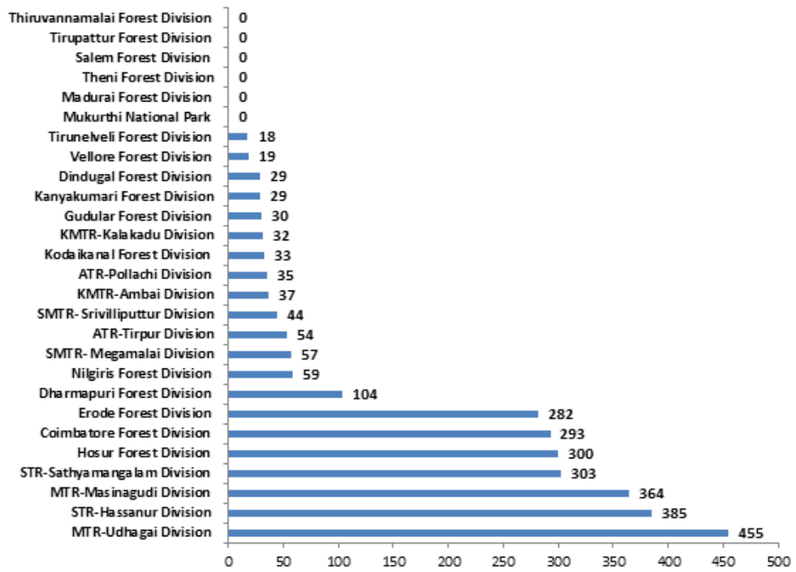

Thiruvannamalai Forest Division 0
Tirupattur Forest Division 0
Salem Forest Division 0
Theni Forest Division 0
Madurai Forest Division 0
Mukurthi National Park 0
Tirunelveli Forest Division 18
Vellore Forest Division 19
Dindugal Forest Division 29
Kanyakumari Forest Division 29
Gudular Forest Division 30
KMTR-Kalakadu Division 32
Kodaikanal Forest Division 33
ATR-Pollachi Division 35
KMTR-Ambai Division 37
SMTR- Srivilliputtur Division 44
ATR-Tirpur Division 54
SMTR- Megamalai Division 57
Nilgiris Forest Division 59
Dharmapuri Forest Division 104
Erode Forest Division 282
Coimbatore Forest Division 293
Hosur Forest Division 300
STR-Sathyamangalam Division 303
MTR-Masinagudi Division 364
STR-Hassanur Division 385
MTR-Udhagai Division 455
0 50 100 150 200 250 300 350 400 450 500

Table 8: Estimated elephant dung density, elephant density, and elephant population in Tamil Nadu using line transect dung count method

Sl. No	Name of the Division	No. of Line Transect	Total length of transects (km)	Total no. of dung recoded	Dung density (No./km²)	SE	LCL	UCL	Elephant density (No./ km²)	SE	LCL	UCL	Estimated elephant population
1	MTR-Udhagai Division	24	49.42	560	3181.1	582.02	2198.9	4602.2	1.89	0.52	1.11	3.22	455
	Mukurthi National Park	4	8	7	NA	NA	NA	NA	NA	NA	NA	NA	NA
2	MTR-Masinagudi Division	33	66.49	343	1767.8	326.77	1230.5	2539.8	1.05	0.29	0.61	1.70	364
3	Nilgiris Forest Division	14	29	127	716.37	309.51	295.9	1734.3	0.42	0.20	0.16	1.09	59
4	Gudular Forest Division	30	60	110	342.39	66.47	232.63	503.93	0.2	0.05	0.01	0.35	30
5	ATR-Pollachi Division	34	68	110	169.17	45.577	100.24	285.51	0.10	0.03	0.05	0.19	35
6	ATR-Tirpur Division	53	106	177	157.16	22.78	117.9	209.49	0.09	0.02	0.05	0.15	54
7	Coimbatore Forest Division	42	84	334	914.76	184.12	614.93	1360.8	0.54	0.15	0.31	0.94	293
8	STR-Sathyamangalam Division	45	90	720	579.65	75.938	445.7	753.84	0.34	0.01	0.21	0.55	303
9	STR-Hassanur Division	30	61	467	1143.8	274.05	718.49	1820.8	0.67	0.21	0.37	1.24	385
10	Erode Forest Division	28	54	398	613.72	93.658	450.52	836.05	0.36	0.09	0.22	0.59	282
11	SMTR-Megamalai Division	68	136.16	210	188.16	31.024	135.74	260.84	0.11	0.02	0.06	0.18	57
12	SMTR-Srivilliputtur Division	34	68	56	174.15	45.649	104.32	290.73	0.10	0.03	0.05	0.19	44
13	Madurai Forest Division	3	6	4	NA	NA	NA	NA	NA	NA	NA	NA	NA
14	Theni Forest Division	4	8	17	NA	NA	NA	NA	NA	NA	NA	NA	NA
15	KMTR-Ambai Division	37	71	76	152.01	30.783	102.16	226.18	0.09	0.02	0.05	0.15	37
16	KMTR-Kalakadu Division	35	69.7	87	191.57	44.134	122.08	300.61	0.11	0.03	0.06	0.20	32
17	Kanyakumari Forest Division	18	36	55	119.68	43.76	56.877	251.84	0.08	0.03	0.03	0.19	21
18	Tirunelveli Forest Division	35	70	96	153.85	32.406	101.28	233.71	0.09	0.02	0.05	0.16	18
19	Dindugal Forest Division	13	27.8	69	290.07	151.3	100.78	834.91	0.17	0.09	0.05	0.52	29
20	Kodaikanal Forest Division	17	34	63	400.62	125.63	214.38	748.66	0.23	0.08	0.11	0.49	33
21	Salem Forest Division	1	2	21	NA	NA	NA	NA	NA	NA	NA	NA	NA
22	Dharmapuri Forest Division	15	30	180	479	154.44	244.91	936.84	0.28	0.10	0.13	0.60	104
23	Hosur Forest Division	40	82	755	508.72	75.16	378.16	684.35	0.30	0.07	0.18	0.50	300
24	Tirupattur Forest Division	4	8	4	NA	NA	NA	NA	NA	NA	NA	NA	NA
25	Vellore Forest Division	17	34	85	92.58	40.96	37.78	226.85	0.05	0.002	0.002	0.14	19
26	Thiruvannamalai Forest Division	3	6	1	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Total	681	1364.57	5125	682.13	43.29	602.32	772.5	0.37	0.08	0.24	0.56	3326

Table 9: Estimated elephant dung density, elephant density and elephant population in elephant reserves of Tamil Nadu using line transect dung count method

Sl. No	Name of the Elephant Reserve	No. of Line Transects	Total length of transects (km)	Total no. of dung recoded	Dung density (No./km²)	SE	LCL	UCL	Elephant density (No./km²)	SE	LCL	UCL	Estimated elephant population
1	Nilgiris Eastern Ghats (Nilgiris)	259	529	3659	1337	87.49	1175	152.06	0.79	0.17	0.52	1.21	3564
2	Nilambur-Silent Valley-Coimbatore (Nilambur)	46	92	341	801.59	159.9	540.85	1188	0.47	0.13	0.27	0.82	277
3	Periyar (Srivalliputhur)	142	274.63	379	280	38.218	214.32	365.82	0.16	0.04	0.10	0.27	200
4	Anamalai-Parambikulam (Anamalai)	117	235.5	419	220.15	31.689	166.07	291.83	0.13	0.03	0.08	0.21	164
5	Agasthyamalai	89	177.41	217	183.36	23.82	141.99	236.79	0.10	0.002	0.006	0.17	105

Table 10: Estimated elephant dung density, elephant density and elephant population in landscapes of Tamil Nadu using line transect dung count method

Sl. No	Name of the landscapes	No. of Line Transects	Total length of transects (km)	Total no. of dungs recoded	Dung density (No./km²)	SE	LCL	UCL	Elephant density (No./km²)	SE	LCL	UCL	Estimated elephant population
1	Western Ghats	498	992.38	2488	498.67	46.619	415.28	598.8	0.31	0.07	0.20	0.48	1523
2	Eastern Ghats	183	365	2026	469.3	33.514	407.69	540.21	0.28	0.06	0.18	0.43	1134

4.3 WATERHOLE COUNT

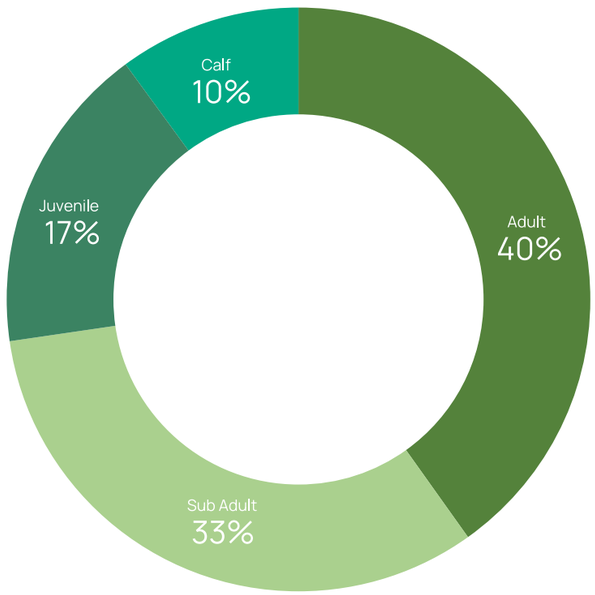
Population Structure

Assessing the demography of populations requires a large number of observations to accurately capture the age and sex distribution. For this analysis, only four forest divisions with a substantial number of elephant sightings (above 35 individuals or more) were considered, while divisions with limited sightings were excluded. Thus, data from four divisions were analysed, and the results are presented in table 11. A total of 178 elephants were observed in areas with greater visibility across four forest divisions.

The overall age-sex composition of the 178 elephants revealed that 40 % were adults, 33% were sub-adult, 17 % were juvenile and 10 % were calf in Tamil Nadu. The different age-sex composition revealed that 23 % were adult females and 14 % were adult males, 21% were sub-adult females and 09 % were sub adult males, 11 % were juvenile females and 05 % were juvenile males, 10 % were calf's in Tamil Nadu (Table 11).

The overall (four divisions combined) male: female (Adult, sub adult, juvenile) sex ratio was 1:2.03, adult male (bull): adult female (cow) sex ratio was 1:1.67, sub-adult male: sub-adult female ratio was 1:2.41, adult female: calf ratio was 1:0.40 and tusker: makhna ratio was 1:0.08. The sex ratio of the elephant population for four forest divisions was given in table 12.

Age Based Elephant Population 2024



Year Wise Elephant Population In Tamil Nadu

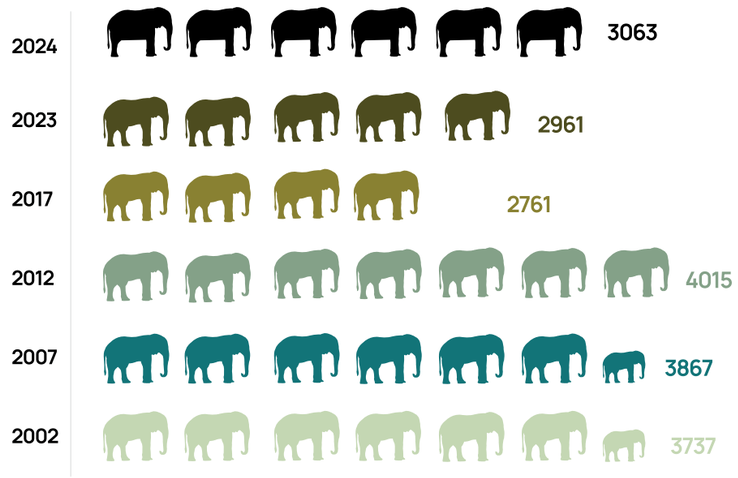


Table 11: Percentage-wise population structure of elephants in four forest divisions in Tamil Nadu during SEPE 2024

Sl. No	Name of the Division	Elephant Classification (%)						
		AF	SAF	JF	AM	SAM	JM	C
1	MTR-Udhagai Division	25	16	18	9	14	11	7
2	MTR-Masinagudi Division	22	32	6	18	12	2	8
3	Gudular Forest Division	45	5	8	26	5	0	11
4	ATR-Tirpur Division	13	35	17	9	7	4	15
Total		**25**	**23**	**12**	**15**	**9**	**6**	**10**

Table 12: Sex ratio of elephants in four forest divisions of Tamil Nadu during SEPE 2024

Sl.No	Name of the Division	Block and Waterhole count			
		AM:AF	SAM:SAF	AF:C	T:M
1	MTR-Udhagai Division	1: 2.75	1: 1.17	1: 0.27	1: 0.15
2	MTR-Masinagudi Division	1: 1.22	1: 2.67	1: 0.36	NA
3	Gudular Forest Division	1: 1.70	1: 1.00	1: 0.24	1: 0.20
4	ATR-Tirpur Division	1: 1.50	1: 5.33	1: 1.17	NA
	Total	1:1.67	1:2.41	1:0.40	1:0.08

5. Summary

Total of 1117 elephants were counted from 681 sample blocks covering an area of 3277.87 Sq.km out of 8989.63 Sq.km of elephant habitats of 26 forest divisions in Tamil Nadu. The estimated population size was 3063 elephants for the states with 95% lower and upper confidence interval varying from 3054 to 3071 elephants. Elephant density was 0.34 per Sq.km in Tamil Nadu. In line transect (dung count), the estimated population size was 3326 elephants for the states and elephant density was 0.37 per Sq.km. The adult populations (40 %) were a higher percentage of the whole elephant populations. Overall male: female sex ratio was 1:2.03 and adult female: calf ratio was 1:0.40 in Tamil Nadu.

6. Discussions

Population density and age structure are essential for understanding the population biology of species. Estimating proper density and age composition is essential for assessing the habitat and population management of endangered species (Riddle et al., 2010). Present elephant density was 0.34/ Sq.km in block count and 0.37/ Sq.km in dung count in the State. This density was corresponding with previous synchronized elephant population estimation conducted in Tamil Nadu during 2023 (0.34/ Sq.km), 2017 (0.37/ Sq.km) and 2010 (0.35/ Sq.km).

Among the 26 forest divisions, MTR- Udhagai & Masinagudi, Gudalur, STR- Sakthi & Hassanur and Hosur forest divisions had the highest population and density of elephants with a substantial proportion of elephant numbers of the state. These six forest divisions are within Nilgiri ER highlighting the importance of this Reserve for the elephants of Tamil Nadu.

The Nilgiri ER and Coimbatore ER have the highest density and estimated population of elephants among the five ERs of the state. The elephants of these two (Nilgiri and Coimbatore) ERs could be treated as a single large population nearly 70–80% of the total number of elephants in the state. Further, these two ERs are contiguous with Wayanad and Nilambur ERs of Kerala; and Mysore ER of Karnataka, and are collectively called Nilgiri-Eastern Ghats landscape. This harbours the largest population of wild Asian elephants found in Asia (Baskaran, 2013). The elephant populations found in the elephant reserves of Tamil Nadu are part of the larger elephant populations that range into the adjoining states of Karnataka and Kerala. Therefore, marginal variation in the total number of elephants between 2023 and 2024 is expected due to movement of the elephants to the adjoining state elephant habitats that are contiguous with those in Tamil Nadu.

Dung decay rate was one of the key variables required to estimate elephant density using the indirect dung-count method. In the absence of specific data of dung decay rate for each forest division, used decay rate of 0.0097 dung piles/ day (SE = 0.002) calculated by Varma et al. (1995) at Mudumalai Wildlife Sanctuary in the present analysis. Dung decay may vary widely across the regions and seasons depending on local conditions of rainfall, temperature and other factors. Therefore, using results of dung decay rate from one division to other divisions cannot necessarily be expected to give a reliable estimate of elephant density at other locations. For the reasons the elephant estimated by sample block count and line transect dung count methods varied significantly in most of the forest divisions. Therefore, it is suggested that require forest divisions wise dung decay rate the population estimate by dung count estimation be conducted in a better manner to obtain a reliable and precise estimate of elephant numbers.

The age-corrected estimates provide insight into the population's age structure. Present age-specific population estimates indicate that more adult elephants (40 %) in the population than other age-structures. Adult dominated age-structures are common in Asian Elephant populations given their long life span and slow reproductive rate (Eisenberg and Lockhart, 1972; Chandran, 1990; Katugaha et al., 1999). Elephants are polygynous species with an expected equal sex ratio at birth. A normal male to female ratio for elephants would be 1:1.87 and 1:1.85 as reported for Rajaji National Park (Williams, 2007) and Ruhuna National Park, Sri Lanka (Katugaha et al., 1999) respectively. Similar normal male to female ratio for elephants was noticed present synchronized elephant population estimation 2024 in Tamil Nadu (M:F 1:2.03, AM: AF 1:1.67 and SAM: SAF 1:2.41). Earlier studies reported a highly skewed sex ratio (AM: AF) of 1:5.6 (2002) and 1:4.6 (2010) in the Tamil Nadu due to selective poaching of males in past decades. Sukumar et al. (1998) reported that, 336–388 elephants were poached in Western Ghats from 1974 to 1994.

A variation was observed for sex ratio between present SEPE 2024 and previous SEPE from 2023 in Tamil Nadu. The variations over the years in the age-sex ratios could possibly be due to the nature of surveys (carried out only for two days in a year and especially during the peak summer season when animals tend to congregate at locations with abundant food and water resources). A study conducted by Gupta et al. (2016) revealed that there was considerable variability in adult sex ratios even within months across dry season. Differences in the detectability of males and females can also bias the sex ratios if the total count of males and females are used. Changes in the count of single males in the population over the years could also be attributed to the dispersal of pubertal males not just from their natal herds but also from their natal home ranges to various locations. Thus, individual turnover in an area due to dispersal males could give fluctuations. Estimates of precise elephant sex-ratio with individual identification only could yield accurate results and thus, systematic long-term studies on sex-ratios in representative populations need to be carried out in the State concurrently to validate the present estimates.

7. Recommendations

Recommended block size (5 Sq.km or less) was not properly followed for some forest divisions during block count survey. Perambulating over five square kilometer would be practically difficult for the census team. Unless measured and marked prominently, it is not possible to have a uniform sample block area in any of the forest divisions. The forest divisions should mandatorily prepare a map and shape file of elephant distribution (present & past) and sample block (5 Sq.km or less) in beat wise of all elephant ranging forest ranges, preferably digitized accurately using standard GIS software. This basic mapping should be completed by at least one month prior to the field enumeration.

Strongly recommend that forest divisions begin setting up dung decay rate (Dry & Wet session) experiments at least 2 to 3 months prior to the field exercise of line transects for estimating dung density.

Adequate number of equipment, necessary for the exercise, including GPS or smart phone app, binocular, DSLR camera and measuring tapes need to be supplied to all forest divisions.

During the age and sex classification

(waterhole count) carried out by the frontline staffs have used visual methods of classifying elephants into 4 age categories. Using photographs could greatly improve the accuracy of classification of elephants.

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